

What is claimed is:

1. A plasma processing apparatus for performing a processing on a to-be-treated substrate mounted on a mounting table in a processing vessel by plasma of a processing gas, comprising:

a ring member formed of an insulating material and installed to surround the to-be-treated substrate on the mounting table;

one or more electrodes installed in the ring member; and

a DC power supply for applying a DC voltage to the one or more electrodes to adjust a plasma sheath region above the ring member.

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2. The plasma processing apparatus of claim 1, further comprising a means for varying the applied voltage such that a first DC voltage is applied to the one or more electrodes when a first process is performed on the to-be-treated substrate and a second DC voltage is applied to the one or more electrodes when a second process is performed on the to-be-treated substrate.

3. The plasma processing apparatus of claim 2, wherein the first process is etching of a thin film and the second process is etching of another thin film which is different

from the thin film in the first process.

4. The plasma processing apparatus of claim 1, wherein the one or more electrodes in the ring member are installed
5 along a diametrical direction and respective DC voltages applied to the one or more electrodes are adjusted independently.

5. A ring member in a plasma processing apparatus for
10 performing a processing on a to-be-treated substrate mounted on a mounting table in a processing vessel by a plasma of a processing gas, wherein the ring member is formed of an insulating material and installed to surround the to-be-treated substrate on the mounting table, wherein the ring
15 member comprises:

one or more electrodes, installed in the ring member, to each of which a DC voltage is applied to adjust a plasma sheath region above the ring member.

20 6. The ring member of claim 5, wherein a first DC voltage is applied to the one or more electrodes when a first process is performed on the to-be-treated substrate and a second DC voltage is applied to the one or more electrodes when a second process is performed on the to-be-treated
25 substrate.

7. The ring member of claim 6, wherein the first process is etching of a thin film and the second process is etching of another thin film from which is different from the thin film in the first process.

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8. The ring member of claim 5, wherein the one or more electrodes in the ring member are installed along a diametrical direction and respective DC voltages applied to the one or more electrodes are adjusted independently.

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9 A plasma processing method, comprising the steps of:
mounting a to-be-treated substrate on a mounting table in a processing vessel;

15 executing a first process on the to-be-treated substrate by generating plasma in a processing vessel under a condition in which a first DC voltage is applied to an electrode for adjusting a plasma sheath region, which is installed in a ring member formed of an insulating material and installed to surround the to-be-treated substrate on the
20 mounting table; and

executing a second process on the to-be-treated substrate by generating plasma in the processing vessel under a condition in which a second DC voltage is applied to the electrode for adjusting the plasma sheath region.

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10. The ring member of claim 5, further comprising:

a base material; and

a film formed by thermal spraying of ceramic on a surface of the base material,

wherein the film is formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of the film is sealed by a resin.

11. The ring member of claim 5, further comprising:

a base material; and

a film formed by thermal spraying of ceramic on a surface of the base material,

wherein the film has a first ceramic layer formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd and a second ceramic layer formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of at least one of the first and the second ceramic layer is sealed by a resin.

12. The ring member of claim 10, wherein the resin is selected from the group consisting of SI, PTFE, PI, PAI, PEI, PBI and PFA.

13. The ring member of claim 5, further comprising:

a base material; and

a film formed by thermal spraying of ceramic on a surface of the base material,

wherein the film is formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of the film is sealed by a sol-gel method.

14. The ring member of claim 5, further comprising:

a base material; and

a film formed by thermal spraying of ceramic on a surface of the base material,

wherein the film has a first ceramic layer formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and a second ceramic layer formed of ceramic including at least one kind of element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd, and at least a portion of at least one of the first and the second ceramic layer is sealed by a sol-gel method.

15. The ring member of claim 13, wherein a sealing treatment is executed by using an element selected from elements in the Group 3a of the periodic table.

16. The ring member of claim 10, wherein the ceramic is at

least one kind selected from the group consisting of B_4C , MgO , Al_2O_3 , SiC , Si_3N_4 , SiO_2 , CaF_2 , Cr_2O_3 , Y_2O_3 , YF_3 , ZrO_2 , TaO_2 , CeO_2 , Ce_2O_3 , CeF_3 and Nd_2O_3 .

5 17. The ring member of claim 5, further comprising:

a base material; and

a film formed on a surface of the base material,

wherein the film has a main layer formed by thermal spraying of ceramic and a barrier coat layer formed of
10 ceramic including an element selected from the group consisting of B, Mg, Al, Si, Ca, Cr, Y, Zr, Ta, Ce and Nd.

18. The ring member of claim 17, wherein the barrier coat layer is formed of at least one kind of ceramic selected
15 from the group consisting of B_4C , MgO , Al_2O_3 , SiC , Si_3N_4 , SiO_2 , CaF_2 , Cr_2O_3 , Y_2O_3 , YF_3 , ZrO_2 , TaO_2 , CeO_2 , Ce_2O_3 , CeF_3 and Nd_2O_3 .

19. The ring member of claim 17, wherein the barrier coat layer is a thermally sprayed film at least a portion of
20 which is sealed by a resin.

20. The ring member of claim 19, wherein the resin is selected from the group consisting of SI, PTFE, PI, PAI, PEI, PBI and PFA.

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21. The ring member of claim 17, wherein the barrier coat

layer is a thermally sprayed film at least a portion of which is sealed by a sol-gel method.

22. The ring member of claim 21, wherein a sealing
5 treatment is performed by using an element selected from elements in the Group 3a of the periodic table.

23. The ring member of claim 5, further comprising:
a base material; and
10 a film formed on a surface of the base material,
wherein the film has a main layer formed by thermal spraying of ceramic and a barrier coat layer formed of engineering plastic formed between the base material and the main layer.

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24. The ring member of claim 23, wherein the engineering plastic is a plastic selected from the group consisting of PTFE, PI, PAI, PEI, PBI, PFA, PPS, and POM.

20 25. The ring member of claim 23, wherein the main layer is formed of at least one kind of ceramic selected from the group consisting of B_4C , MgO , Al_2O_3 , SiC , Si_3N_4 , SiO_2 , CaF_2 , Cr_2O_3 , Y_2O_3 , YF_3 , ZrO_2 , TaO_2 , CeO_2 , Ce_2O_3 , CeF_3 and Nd_2O_3 .

25 26. The ring member of claim 5, further comprising:
a base material; and

a film formed on a surface of the base material,
wherein the film is formed of ceramic including at
least one kind of element in the Group 3A of the periodic
table and at least a portion of the film is hydrated by
5 vapor or high temperature hot water.

27. The ring member of claim 5, further comprising:
a base material; and
a film formed on a surface of the base material,
10 wherein the film has a first ceramic layer formed of
ceramic including at least one kind of element in the Group
3a of the periodic table and a second ceramic layer formed
of ceramic including at least one kind of element in the
Group 3a of the periodic table, and at least a portion of at
15 least one of the first and the second ceramic layers is
hydrated by vapor or high temperature hot water.

28. The ring member of claim 26, wherein the film is a
thermally sprayed film formed by thermal spraying or a thin
20 film formed by a thin film formation technique.

29. The ring member of claim 26, wherein the film is
formed of ceramic selected from Y_2O_3 , CeO_2 , Ce_2O_3 and Nd_2O_3 .

25 30. The ring member of claim 5, further comprising:
a base material; and

a film formed on a surface of the base material,
wherein the film has a first ceramic layer formed of ceramic including at least one kind of element in the Group 3a of the periodic table and a second ceramic layer formed by thermal spraying of ceramic, and at least a portion of the first ceramic layer is hydrated by vapor or high temperature hot water.

31. The ring member of claim 30, wherein the first ceramic layer is a thermally sprayed film formed by thermal spraying or a thin film formed by a thin film formation technique.

32. The ring member of claim 30, wherein the first ceramic layer is formed of ceramic selected from the group consisting of Y_2O_3 , CeO_2 , Ce_2O_3 and Nd_2O_3 .

33. The ring member of claim 30, wherein the second ceramic layer is formed of at least one kind of ceramic selected from the group consisting of B_4C , MgO , Al_2O_3 , SiC , Si_3N_4 , SiO_2 , CaF_2 , Cr_2O_3 , Y_2O_3 , YF_3 , ZrO_2 , TaO_2 , CeO_2 , Ce_2O_3 , CeF_3 and Nd_2O_3 .

34. The ring member of claim 5, further comprising:
a base material; and
a film formed on a surface of the base material,
wherein the film has a hydroxide layer formed of

hydroxide including at least one kind of element in the Group 3a of the periodic table.

35. The ring member of claim 34, wherein the hydroxide
5 layer is a thermally sprayed film formed by thermal spraying
or a thin film formed by a thin film formation technique.

36. The ring member of claim 34, wherein the hydroxide
layer is formed of hydroxide selected from $Y(OH)_3$, $Ce(OH)_3$
10 and $Nd(OH)_3$.

37. The ring member of claim 34, wherein at least a
portion of the hydroxide layer is sealed.

38. The ring member of claim 10, further comprising an
15 anodic oxidized film formed between the base material and
the film.

39. The ring member of claim 38, wherein the anodic
20 oxidized film is sealed by an aqueous solution of metal salt.

40. The ring member of claim 38, wherein the anodic
oxidized film is sealed by a resin selected from the group
consisting of SI, PTFE, PI, PAI, PEI, PBI and PFA.

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41. The ring member of claim 5, wherein the ring member is

formed of a sintered ceramic body including at least one kind of element in the Group 3a of the periodic table, and at least a portion of the sintered ceramic body is hydrated by vapor or high temperature hot water.

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42. The ring member of claim 41, wherein the sintered ceramic body is formed by hydrating ceramic selected from the group consisting of Y_2O_3 , CeO_2 , Ce_2O_3 and Nd_2O_3 .

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43. The ring member of claim 5, wherein the ring member is formed of a sintered ceramic body including a hydroxide having at least one kind of element in the Group 3a of the periodic table.

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44. The ring member of claim 43, wherein the hydroxide included in the sintered ceramic body is selected from the group consisting of $Y(OH)_3$, $Ce(OH)_3$ and $Nd(OH)_3$.